Extending Cloud Computing on Mobile Platform

Piyush R. Joshi, Prof. C. S. Dhamande, Yash S. Pahuja

Abstract— Today there is an enormous growth in the number of mobile phone users and also in the mobile applications, together with the emerging of Cloud Computing (CC), the concept of Mobile Cloud Computing (MCC) has been introduced. MCC is the Combination of Cloud Computing and Mobile Computing. The emerging cloud computing technology offers a natural solution to extend the limited capabilities of mobile devices. Cloud facilities appear as a promising option that enables mobile devices-clients to offload their tasks to remote cloud servers. The term "Mobile Cloud Computing" basically, refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. Mobile cloud computing can be applied to the applications installed in mobile devices to increase the processing speed and optimize operations to attain efficient results.

Index Terms— Cloud Computing (CC), Cloud Servers, Iaas, Mobile Computing, Mobile Cloud Computing (MCC), Paas, Offloading

1 Introduction

THE combination of cloud computing, wireless communication infrastructure, portable computing devices, mobile Web, etc., has laid the foundation for a new computing model, called mobile cloud computing. Many Advances in cloud computing have made it possible to provide infrastructure, platform, and software as services for users from any computer with an Internet connection. Mobile cloud computing then extends such services to mobile devices. There are several billions of mobile phone subscribers world-wide, so mobile cloud computing has the potential to have far reaching impacts in the wireless industry and in our society. Mobile devices such as smartphones, tablet PCs, notebooks etc. have become an essential part of our life. Advancements in the field of wireless network communication (for e.g. Wi-Fi, Wi-Max, 3G, etc.) in the last few years have led to huge growth of applications on mobile platform. The rapid progress of mobile computing (MC) [1] becomes a powerful trend in the development of IT services as well as commerce and industry fields. Mobile cloud computing brings new types of services and facilities for mobile users to take full advantages of cloud computing.

The recent trend in the internet is the tremendous increase in the popularity of video and interactive video services (e.g., video conferencing and online gaming). With the tremendous increase mobile devices, people are more interested to watch video and play online games on mobile devices. According to a recent study [2], among all the mobile data traffic across the world, 66.5 percent will be video related by 2017. This number was 51 percent by the end of 2012. However, the mobile devices are facing many challenges in their resources (e.g., battery life, storage, and bandwidth). It is forecasted that cloud applications will account for 84 percent of the total mobile data traffic in 2017, compared to 74 percent by the end of 2012.

- *Piyush R. Joshi B.E. C.S.E. Amrawati University, India. E-mail: piyush-nfs@gmail.com*
- *Prof. C.S. Dhamande M.Tech. C.S.E., India. E-mail: chetan.dhamande@gmail.com*
- *Yash S. Pahuja B.E. C.S.E. Amrawati University, India. E-mail: yashphuja1125@gmail.com*

Fig. 1.1 shows the increase of cloud data traffic from 2012 to 2017. So Mobile Cloud Computing is a promising solution to fill the gap between the mobile multimedia demand and the capability of mobile devices.

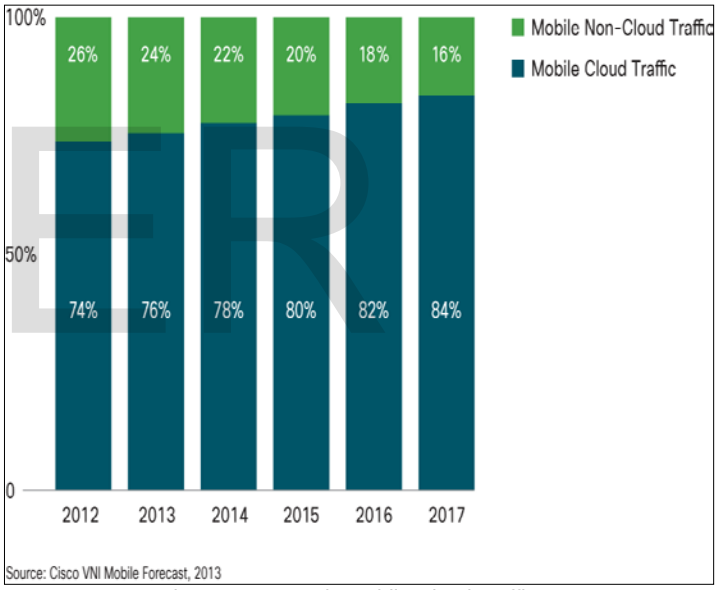


Fig. 1.1 Increase in Mobile Cloud Traffic

Mobile Cloud Computing (MCC) intends to make the advantages of Cloud Computing available for mobile users but will provide additional functionality to the"cloud" as well. Mobile Cloud Computing (MCC) will help to overcome limitations of mobile devices in particular of the processing power and data storage. It might also help to extend the battery life by moving the execution of commutation-intensive application to the cloud.

2 Cloud Computing

Cloud Computing is a computing model, not a technology. Cloud computing is a new model in which various computing resources for example memory, processing and storage are phyically present at the service provider's locationand not the user's location. That is, a service provider owns and maintains these resources, and users only access them through the Internet. Cloud computing promises a more cost effective enabling

technology to outsource storage and computations. Cloud computing (CC) has been widely recognized as the next generation's computing infrastructure.Cloud offers many advantages by allowing users to use infrastructure (e.g., servers, networks, and storages), platforms (e.g., middleware services and operating systems), and softwares (e.g., application programs) provided by cloud providers (e.g., Google, Amazon) at low cost. In addition, CC enables users to elastically utilize resources in an on-demand fashion. As a result, with the assistance of CC mobile applications can be quickly executed and released with the minimal management efforts or service provider's interactions.

A more formal definition that includes the key benefits of cloud computing from a business perspective as well as its unique features from a technological perspective given by Sean Martsonet al. [3] in their research paper is as follows:
"It is an information technology service model where computing services (both hardware and software) are delivered on demand to customers over a network in a self-service fashion, independent of device and location. The resources required to provide the requisite quality-of service levels are shared, dynamically scalable, rapidly provisioned, virtualized and released with minimal service provider interaction. Users pay for the service as an operating expense without incurring any significant initial capital expenditure, with the cloud services employing a metering system that divides the computing resource in appropriate blocks."

2.1 Cloud computing Features

Cloud Computing brings features that distinguish it from classical resource and other computing models, they are as listed follows,

2.1.1 Less capital expenditure - Cloud computing does not require upfront investment. No capital expenditure is required. Users may pay and use or pay for services and capacity as they need them.

2.1.2 Highly Scalable –Cloud computing provides resources and services for users on demand. The user can scale up or scale down resources over several data centers.

2.1.3 Higher resource Utilization - Cloud computing can guarantee Quality of Service (QoS) for users in terms of hardware or CPU Utilization, bandwidth and memory capacity.

2.1.4 Device and Location Independence - The user can access the multiple data servers from any location at a go.

2.2 Cloud Computing Service Models

Fig 2.1 presents Cloud Computing service models [4], [5].

2.2.1 Software as a Service (SaaS) - It is a model of software deployment whereby the provider licenses an application to the customers for use as a service on demand. The capability provided to the End users is to use the provider's applications running on a cloud infrastructure. The software applications can be accessed from various client devices through a thin client interface such as a web browser (e.g., web enabled e-mail). The end users does not manage or control the underlying cloud infrastructure that includes servers, databases, network, operating systems, storage, or even individual application capabilities, with the possible exception of limited user specific application configuration settings. Today SaaS is offered by companies such as Microsoft, Google, Salesforce, Zoho, etc.

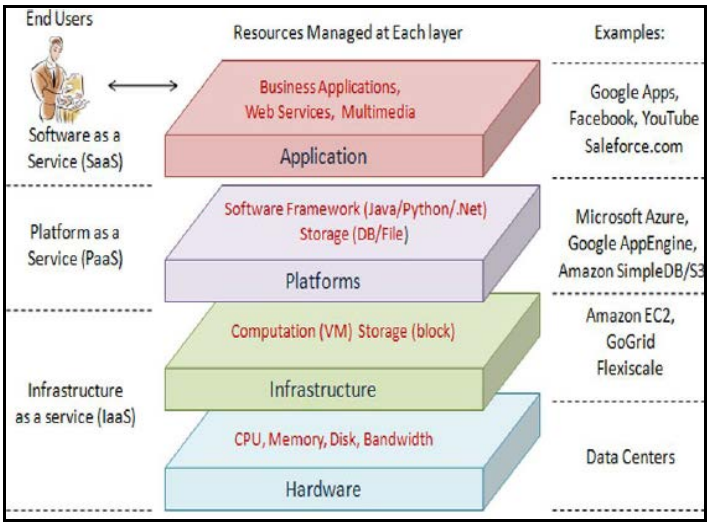


Fig. 2.1 Cloud Computing Service Models

2.2.2 Platform as a Service (PaaS) - It is the delivery of computing platform and solution stack as a service. The capability provided to the end users is to deploy onto the cloud infrastructure user created or acquired applications created using programming languages and tools supported by the provider. The end user does not manage or control the underlying cloud infrastructure including network, servers, operating systems, databases or storage. PaaS providers offer a predefined combination of OS and application servers, such as WAMP platform (Windows, Apache, MySql and PHP), LAMP platform (Linux, Apache, MySql and PHP), and XAMP(X-cross platform) limited to J2EE, and Ruby etc. Google App Engine, Salesforce.com, etc are some of the popular PaaS examples.

2.2.3 Infrastructure as a Service (IaaS) - It is the delivery of computer infrastructure (typically a platform virtualization environment) as a service. The capability provided to the end users is to access and provision processing, storage, networks, databases and other fundamental computing resources where the end user can deploy and run arbitrary software, which can include operating systems, programming languages, development tools and applications. The user does not maintain or control the underlying cloud infrastructure but it has control over the platform that is operating systems, databases, storage, deployed applications, and some limited control of select networking components. Some of the common examples of Paas are Amazon, GoGrid, 3tera, etc.

3 Mobile Cloud Computing

The Mobile Cloud Computing Forum [6] defines MCC as *"Mobile Cloud computing at its simplest refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud,*

bringing applications and mobile computing to not just smart phone users but a much broader range of mobile subscribers".

3.1 Why Cloud is the Future of Mobile Computing?

Cloud Computing is not limited to the Personal Computer (PC) platform, but now it is extended to the mobile platform. The mobile platform is going to be heavily impacted by this technology. Cloud will soon become a disruptive force on the mobile platform, and becoming the dominant way in which mobile applications operate. Basically in MCC both the data storage and the data processing is carried outside of the mobile device.Today number of popular examples of mobile cloud computing applications including mobile Gmail, Google Maps, Facebook and some navigation apps. However, most of the applications today still do most of the data storage and processing on the mobile devices themselves and not in the cloud. However in next few years, this could change.

4 Mobile Cloud Computing Architecture

In the mobile cloud architecture, mobile devices can access cloud services in two ways, i.e., through mobile network (telecom network) or through access points, as shown in Figure 4.1.

In the case of mobile network (telecom network provider), the mobile devices such as cellular smartphones are connected to a mobile network through a Base Station (BS). The telecom networks are further connected to the Internet and provide Internet connectivity to the users. Therefore, if the users have mobile network connectivity, the users can access cloud based services through the Internet.

In the access point case, the mobile users connect to the access points through Wi-Fi that is further connected to the Internet service provider to provide Internet connectivity to the users. Therefore, the mobile cloud users can access cloud based services without utilizing telecom services, which may charge them for data traffic. Moreover, Wi-Fi based connections provide low latency and consume less energy compared to 3G connections. Consequently, mobile cloud users prefer to use Wi-Fi Internet connections whenever accessible.

Although the client is changed from PCs or fixed machines to mobile devices, still the basic concept is of cloud computing. Mobile users send requests for services to the cloud through a web browser or desktop application. The management component of cloud then assigns resources to the request and establish connection, while QoS is ensured by implementation of monitoring and calculating functions of mobile cloud computing.

The mobile devices are connected to the mobile networks through base stations that establish and control the connections (air interface) and functional interfaces between the networks and mobile devices. Mobile device user's service request and information are sent to the central processors that are connected to the servers providing mobile network services. Here, services such as Authentication, Authorization and Accounting (AAA) can be provided to the users based on Home Agent (HA) and subscribers' data stored in databases. The subscribers' requests are then forwarded to a cloud via the Internet. Cloud controllers located in the Cloud, receives andprocess the requests to provide the mobile users with the requested cloud services.

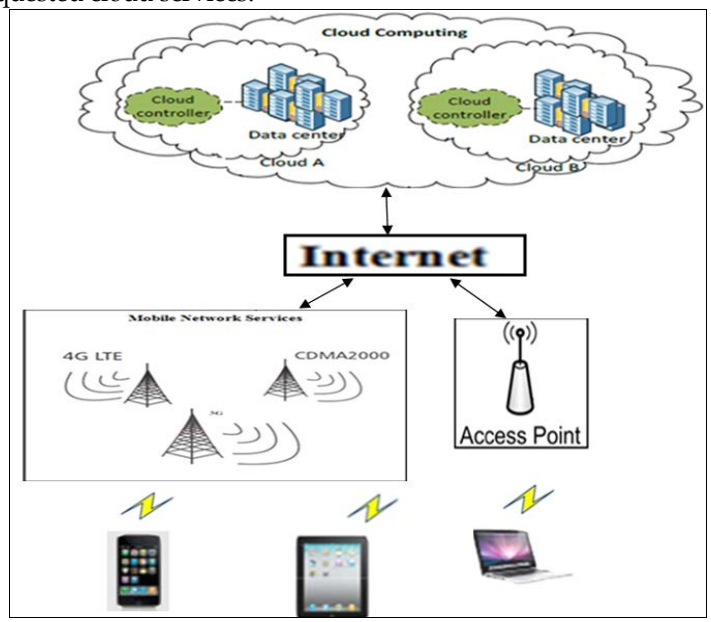


Fig 4.1 Mobile Cloud Computing Architecture

5 Computation Offloading

With the support of the cloud, mobile multimedia applications can be either carried out in the mobile device or in the cloud. Executing computation-intensive applications consumes lots of battery power at the mobile device. So computing intensive applications should be offloaded to and executed in the cloud for energy conservation. To overcome resource constraints on mobile devices, a general idea is to offload parts of resource-intensive tasks to the cloud. Since execution in the cloud is considerably faster than that on mobile devices, it is worth shipping code and data to the cloud and back to prolong the battery life and speed up the application. [7] This offloading framework is illustrated in Fig. 5.1.

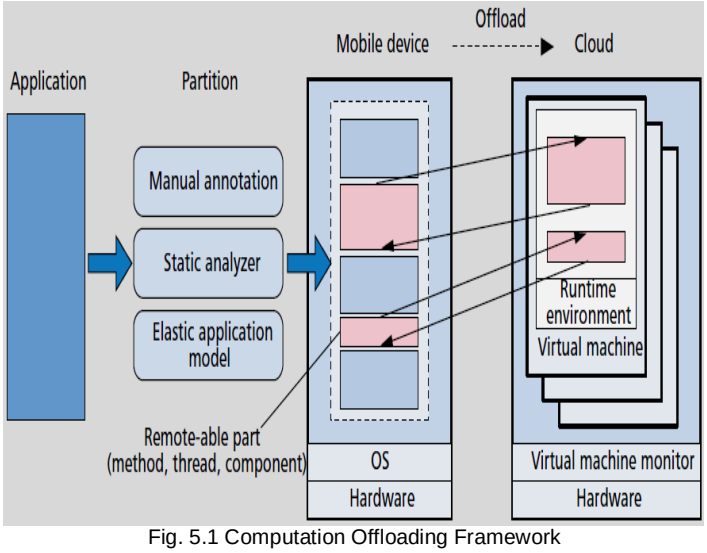
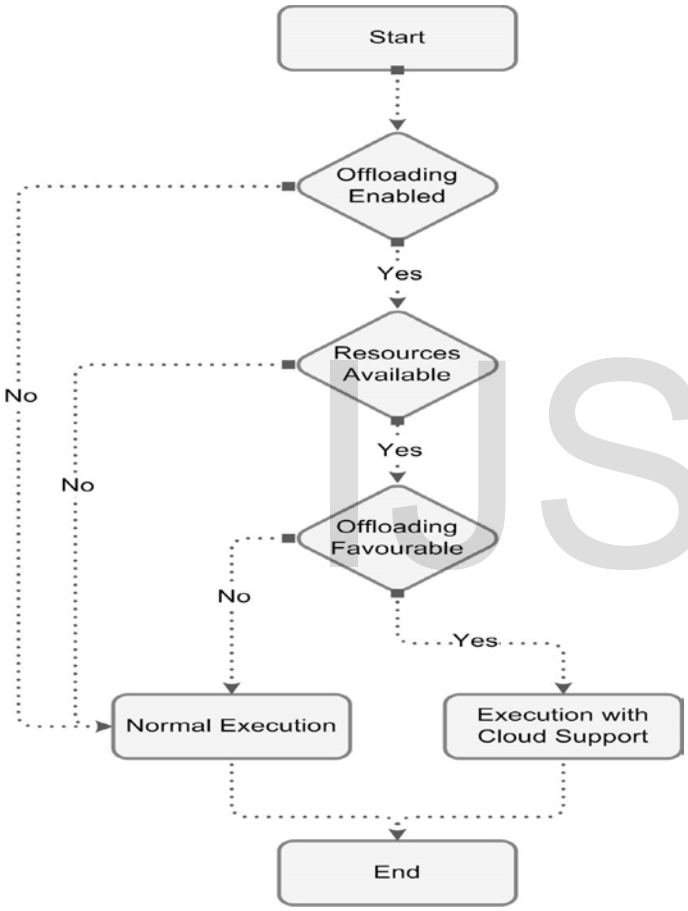


Fig. 5.1 Computation Offloading Framework

Computation offloading is a procedure that migrates resource-intensive computations from a mobile device to the resource-rich cloud, or server (called nearby infrastructure). Cloud based computation offloading improves the applications performance, reduces battery power consumption, and execute applications that are unable to execute due to insufficient Smartphone resources. Moreover, cloud offers storage services that can be used to overcome the storage constraints of the smartphones.

5.1 Computation Offloading Decision Making

A mobile cloud application goes through the following steps before offloading computations to the cloud. [8] Fig 5.2 shows



the basic workflow of the computation offloading process. The workflow starts with the execution of an application followed by checking the user's offloading permission.

Fig 5.2 Computation Offloading decision making process

If offloading is enabled, then application checks connectivity to the cloud resources and notes the available/assigned resources. The next step involves deciding whether offloading is favorable, depending on the users' desired objective. If it is favorable, then the computation offloading is performed. Otherwise, the application performs all computations locally.

6 Applications of Mobile Cloud Computing

Cloud Computing enables enhanced mobile experiences that were previously impossible on resource-constrained mobile devices. Many commercial mobile applications use the cloud to provide rich features to mobile users.Essentially cloud computing helps to increase the capabilities of mobile devices in three aspects: computation, storage, and networking. Mobile applications are increasing their share in a global mobile market. Many mobile applications have taken the benefits of MCC. [9] Gives some typical MCC applications, they are as listed as follows.

6.1 Mobile - Commerce

Mobile commerce (m-commerce) is a business model for commerce using mobile devices. The m-commerce applications generally fulfill some tasks that require mobility (e.g., mobile transactions and mobile payments, mobile messaging, and ticketing). The m-commerce applications have to face many challenges (e.g., low network bandwidth, high complexity of mobile device configurations, and security). So, m-commerce applications are integrated into cloud computing environment to address these issues.

6.2 Mobile - Learning

Mobile learning (m-learning) is designed based on electronic learning (e-learning) with mobility. But, traditional m-learning applications face limitations in terms of high cost of devices and network, slow network transmission rate, and very less educational resources. M-learning applications can be integerated with cloud to overcome these limitations. Since a cloud have large storage capacity and powerful processing ability, the applications can provide learners with more richer services in terms of faster processing speed, data (information) size, and longer battery life.
(M-LEARNING) = (E-LEARNING) + Mobility

6.3 Mobile – Healthcare

The purpose of applying MCC in medical applications is to minimize the limitations of traditional medical treatment (e.g., small physical storage, security and privacy, and medical errors). Mobile healthcare (m-healthcare) provides mobile users with convenient helps to access resources (e.g., patient health records) easily, efficiently and quickly. In addition, m-healthcare offers hospitals and healthcare organizations a variety of on-demand services on clouds rather than owning standalone applications on local servers.

6.4 Mobile – Gaming

Mobile game (m-game) is a potential market that can generate revenues for cloud service providers. Using M game one can completely offload game engine requiring large computing resource (e.g., graphic rendering) to the server in the cloud, and gamers only have to interact with the screen interface on their mobile devices. Offloading (multimedia code) can save energy for mobile devices, and hence increasing game playing time on mobile devices.

6.5 Searching

A cloud becomes the most effective tool when mobile users require searching services (e.g., searching information, location, images, voices, or video clips).

6.5.1 Keyword-based Searching – An intelligent mobile search model in which searching tasks will be performed on servers in a cloud. This search model analyzes the meaning of a word, a phrase, or a complex multi-phase to produce the results quickly and accurately.

6.5.1 Voice-based Searching – A search service via a speech recognition in which mobile users just talks to microphone on their devices rather than typing on keypads or touch screens.

7 CHALLENGES

Although highly promising, mobile cloud computing for multimedia applications is still in its infancy. There are many challenges that need to be investigated to fully harvest its potential. Mobile cloud computing relies on wireless networks (e.g., 3G and Wi-Fi) for data and control between the cloud and mobile devices. Compared with fixed and wired networks, wireless networks have limited bandwidth, probably longer latency, and intermittent connectivity. Moreover, under the presence of more mobile devices, the bandwidth available to each device will be further reduced, and network latency can go up and response time for mobile users can be larger. Following are the some of the limitations of Mobile Cloud Computing.

7.1 Availability

Various network failures and traffic congestion in the network may hinder the mobile users to connect to the cloud and access required services. If there are too many concurrent requests, even if the powerful cloud servers are capable of serving the requests, the wireless links will surely fall short of capacity.

7.2 Security and Privacy

Mobile Cloud Computing is vulnerable to various attacks like Phishing by which one can illegally gain another's passwords and other sensitive information. The open air transmissions of mobile devices and the distributed storage and processing in the cloud make mobile media cloud applications more vulnerable to malicious programs and attacks. As mobile cloud getting more popular, the security issue becomes more and more important. However, mobile devices may not be feasible to run sophisticated computation- intensive anti-virus programs on the mobile device, due to computational and power constraints. Again, we have to resort to the cloud to detect potential vulnerabilities and threats.

7.3 Bandwidth Costs

Unfortunately, Cloud computing, companies can save money on hardware and software; however they could incur higher network bandwidth charges. Bandwidth cost may be low for smaller Internet-based applications, which are not data intensive, but could significantly grow for data-intensive applications.

8 CONCLUSION

Mobile cloud computing will be one of the mobile technology trends since it combines the advantages of both mobile computing and cloud computing, thereby providing optimal services for mobile users.

Although mobile devices geared toward cloud computing will undoubtedly change moile technology trends as well as our daily lives, some practical problems still remains to be resolved to structure a full-fledged mobile cloud system.

The applications supported by mobile cloud computing including mobile commerce, mobile learning, and mobile gaming have been discussed which clearly show the applicability of the mobile cloud computing to a wide range of mobile services.

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